$U_D(t)$ and dc compensation voltage (CV) applied must substantially include the range set by operation of said DMS analyzer. Because of ion focusing in curved geometries, the CV transmission window is always broader for curved than for planar DMS. Hence, in one aspect of the invention, focusing of ions after their separation by a substantially planar DMS analyzer neither affects its high resolution nor causes significant ion losses. However, thinner ion beams created by such focusing are more completely transmitted to subsequent instrument stages through constrained apertures. In another aspect of the invention, ion focusing compresses ion beams upon their injection into DMS, which may reduce non-selective loss of ions injected near electrodes due to diffusion and Coulomb repulsion. As always with curved DMS geometries, strength of ion focusing and thus resulting sensitivity gain tends to increase at higher absolute CV.

[0012] As all asymmetric $U_D(t)$ profiles induce ion focusing in curved DMS, various profiles may be used in the apparatus of invention and the substantially planar DMS coupled thereto or integrated therewith. In particular, rectangular, bisinusoidal, clipped-sinusoidal, and other waveforms known in the art of FAIMS may be employed, without limitation. Waveforms effecting higher-order differential ion mobility spectrometry (HODIMS), where ions are separated primarily by the third (i.e., the 4^{th} power) or higher terms of the polynomial representing the expansion of ion mobility as a function of electric field, may also be used.

[0013] As in DMS systems known in the art, ions may be carried through the apparatus of invention by gas flow, in particular an extension of the flow through the DMS analyzer coupled thereto. Alternatively, ions may be driven through said apparatus by a relatively weak dc component of electric field directed along the gap at each point. Such a field may be created by segmenting curved electrodes of the apparatus longitudinally and applying a ladder of dc voltages to the segments. In an embodiment, those dc voltages and $U_D(t)$ could be co-applied to electrodes using an electronic scheme including capacitors and resistances known in the art, similar to that implemented with ion funnels. The gas flow and longitudinal electric field could be combined in the same device.

[0014] One may desire to couple multiple DMS analyzers to one subsequent instrument stage, e.g., to overcome the charge capacity limitations of a single analyzer or to improve the ionization efficiency and thus analytical sensitivity using multiple ion sources (for example, in ESI), but is not limited thereto. Hence, in an embodiment, one set of curved electrodes receives ions from two or more substantially planar DMS analyzers.

[0015] It may be advantageous to deliver ions from one ion source or instrument stage to multiple DMS analyzers, e.g., to overcome the charge capacity limitation of a single analyzer, but is not limited thereto. Hence, in another embodiment, one set of curved electrodes delivers ions to two or more substantially planar DMS analyzers.

[0016] It is desirable to reduce loss of ions both after injection into DMS and during transmission from DMS to subsequent stages. In an embodiment, the system features two curved electrode sets, one delivering ions to and the other receiving ions from one or more substantially planar DMS analyzers. In particular, two DMS analyzers could be involved.

[0017] DMS separation parameters in the apparatus of invention and the DMS analyzer could be matched using different gap widths (g) and proportional $U_D(t)$ amplitudes (known as dispersion voltage, DV). However, the same (g) and $U_D(t)$ would simplify the instrument design and operation. In an exemplary embodiment, gaps between curved electrodes and between DMS analyzer electrodes have equal width and coincident median at the point of closest mutual proximity, and the same waveform is applied to said curved electrodes and to said DMS analyzer electrodes.

[0018] The apparatus of invention and a substantially planar DMS analyzer could be coupled or integrated more easily or precisely if one or more of the curved electrodes are contiguous with one or more electrodes of the DMS analyzer. In an exemplary embodiment, one curved electrode is contiguous with one planar DMS electrode and the other curved electrode is contiguous with the other planar DMS electrode such that $U_D(t)$ is loaded simultaneously on said curved electrodes and DMS analyzer electrodes coupled thereto or integrated therewith.

[0019] While the invention could use various curved electrode shapes, perhaps the easiest to manufacture are cylinders having cylindrical geometries where DMS ion focusing is best characterized. Hence, in an exemplary embodiment, the curved electrodes are cylindrical segments produced by resection of an angular arc from two coaxial cylinders and positioned such that the cylindrical axis is parallel to the DMS analyzer plane.

[0020] While the angular span of cylindrical parts may vary in the range of from 0 to about 270^0, and more particularly from about 30^0 to about 180^0, a value of ~90^0 in the exemplary embodiment is convenient for design and allows inserting a planar DMS into an MS system without changing orientation of the ion source or other preceding instrument stage.

[0021] In the configuration of the exemplary embodiment, the focusing field strengthens with increasing cylindrical curvature, but the ion path length through it, and thus the ion residence time in the focusing element, decrease: in the limits of zero and infinite curvature, no focusing will occur. Therefore, there must be a finite curvature providing maximum focusing effect, with the optimum depending on ion properties and experimental conditions.

[0022] The cylindrical curvature may be expressed in terms of the radius of annular gap median. The preferred radii would be between about 1 mm and about 100 mm, and more particularly between about 3 mm and about 30 mm. The value of (g) between curved electrodes would preferably be set equal to that in the DMS analyzer described above, but otherwise could be chosen to maximize ion transmission within realistic engineering constraints. Preferred values for atmospheric pressure operation would range between about 0.2 mm and about 10 mm, and more particularly between about 0.4 mm and about 5 mm.

[0023] Operation of DMS analyzers at reduced gas pressure is known in the art to increase resolution, because lower gas number density allows higher normalized electric field without electrical breakdown. The apparatus of invention may use gas at other than atmospheric pressure (P_0) to interface DMS analyzers operated at such other pressure (P_{OP}). In that case, preferred ranges for gap width stated above could be scaled by P_0/P_{OP}. In particular, optimum gaps for reduced-pressure operation would be wider than those selected for operation at 1 atm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** is a cross-sectional view of a "hooked" DMS apparatus, according to one embodiment of the invention.